PTO 07-2625

CC=JA DATE=19971003 KIND=A
PN=9-261180

SPACE TRANSMISSION COMMUNICATION DEVICE
[Kukan denso tsushin sochi]

Shinichi Baba, et al.

UNITED STATES PATENT AND TRADEMARK OFFICE
Washington, D.C. March 2007

Translated by: FLS, Inc.

PUBLICATION COUNTRY	(19):	JP
DOCUMENT NUMBER	(11):	9-261180
DOCUMENT KIND	(12):	A
	(13):	
PUBLICATION DATE	(43):	19971003
PUBLICATION DATE	(45):	
APPLICATION NUMBER	(21):	8-184903
APPLICATION DATE	(22):	19960715
ADDITION TO	(61):	
INTERNATIONAL CLASSIFICATION	(51):	H04B 10/105, 10/10, 10/22, 10/02, 10/18
DOMESTIC CLASSIFICATION	(52):	
PRIORITY COUNTRY	(33):	
PRIORITY DATE	(32):	
PRIORITY NUMBER	(31):	
INVENTORS	(72):	SHINICHI BABA, YASUHIKO SHIMOMURA
APPLICANT	(71):	TOSHIBA CORP
TITLE	(54):	SPACE TRANSMISSION COMMUNICATION DEVICE
FOREIGN TITLE	[54A]:	KUKAN DENSO TSUSHIN SOCHI

[Claims] /2*

[Claim 1] A space transmission communication device comprising a transmitter for converting data into electromagnetic signals with a predetermined bit rate and radiating the signals into space, and a receiver for receiving the electromagnetic signals radiated by the transmitter and regenerating the signals, wherein the device further comprises a reception strength detecting means for detecting the reception strength of the received electromagnetic signals, a bit rate changing means for changing the transmission bit rate in response to the reception strength, and a receiving means for changing the reception bit rate or reception operation for the electromagnetic signals based on the transmission bit rate changed by the bit rate changing means.

[Claim 2] The space transmission communication device described in Claim 1, wherein the electromagnetic signals are optical signals.

[Claim 3] The space transmission communication device described in Claim 1 or Claim 2, wherein the receiving means is equipped with a plurality of receiving elements forming different electromagnetic reception ranges.

[Claim 4] The space transmission communication device described in any one of Claims 1 through 3, wherein the transmitter comprises a first transmission means for forming the main transmission beam and a second transmission means for forming a supplementary transmission beam to the outside of the main transmission beam formed by the first

* Numbers in the margin indicate pagination in the foreign text.

transmission means using a power lower than the radiation power of the main transmission beam.

[Claim 5] The space transmission communication device described in any one of Claims 1 through 4, wherein the transmitter transmits electromagnetic signals with a low bit rate along with signals detectable only by a receiver receiving electromagnetic signals at a high bit rate when the transmitter transmits electromagnetic signals with a low bit rate.

[Claim 6] The space transmission communication device described in Claim 2, wherein the data is baseband signals, wherein these baseband signals are aB1C (a: natural number; a > 1), bBcB (b, c: natural numbers; c = b + 1) or DdB1M (d: natural number; d > 1) encoded, and wherein the low frequency range of the receiver is blocked.

[Claim 7] The space transmission communication device described in Claim 6, wherein the transmitting element in the transmitter for outputting the optical signals is a laser diode.

[Claim 8] A space transmission communication device for converting data to optical signals, radiating these signals into space, and regenerating the data incorporated into the optical signals propagated through space, wherein the propagated data is baseband signals, wherein these baseband signals are aB1C (a: natural number; a > 1), bBcB (b, c: natural numbers; c = b + 1) or DdB1M (d: natural number; d > 1) encoded, and wherein the low frequency range of the receiver is blocked.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention] The present invention relates to a space transmission communication device for transmitting and receiving information using electromagnetic signals radiated into space, whether indoors or outdoors.

[0002]

[Prior Art] Space transmission communication devices used to form a wireless optical link or wireless optical LAN network for transmitting and receiving data use an electromagnetic wireless transmission route such as an infrared wireless transmission route to transmit and receive data. As a result, the individual transmitter/receivers ("transceivers") are portable and can be used when in motion.

[0003] If these electromagnetic transmission routes use light such as laser beams with a short wavelength, data can be transmitted and received at high speeds in a wide band unlike transmission and reception of data using other types of non-optical electromagnetic waves. Because light travels in a fixed straight line, the spatial range in which the space transmission communication devices can be used to transmit and receive data is limited to line of sight. Therefore, management of the transmission range (area) is relatively easy. Also, because a license is not required to operate one of these networks under the Radio Law, these space transmission communication

devices are expected to be used advantageously as B-ISDN terminal wiring means incorporating wire-based networks.

[0004] In recent years, communication devices have been connected to computers such as personal computers on the transmitting and receiving ends in order to send and receive various sorts of data. The optical wireless LAN connection format for data communication is either an optical wireless link type for 1:1 communication, or an optical wireless LAN type for 1:N [N > 1] communication.

[0005] In the optical wireless LAN type for 1:N communication, a master device is installed on the ceiling of a room inside a building, and all slave devices in that room communicate with the master device. A ceiling plate can also be used as a light-reflecting plate so that the communication devices inside the room can conduct 1:N communication or two types of so-called diffusion-type communication.

[0006] In either type of optical wireless LAN, the communication devices communicate via a ceiling plate or master device installed on the ceiling. In this way a wider transmission beam can be used so that the optical transmission route is not blocked by a moving person inside the room or by the installation of other devices. Therefore, communication is not obstructed by small obstacles such as dust, and no strict arrangement is required of the communication devices on the transmitting and receiving ends in terms of antenna directionality, or transmission beam and reception line-of-sight patterns. A transmission route may be blocked temporarily by an object larger than the width of the transmission beam, or affected temporarily by an object smaller

than the width of the transmission beam. However, if the data transmission speed is not too fast, some transmitted data can be stored temporarily in the buffer on the transmitting end until the transmission route is reopened. When the obstacle is removed from the transmission route, the data stored in the buffer is transmitted. In this way, continued communication can be ensured.

[0007] However, the wireless LAN terminal device connected to /3 the internet via a gateway device will have to process a large amount of high-speed data as B-ISDN continues to develop in the future. Consequently, a single buffer will no longer be able to handle temporary disruptions in communication.

[0008] Because optical transmission can use broadband transmission, high-speed data transmission is possible. However, because broadband transmission leads to deterioration in noise tolerance, higher transmission signal power is required to maintain the signal-to-noise ratio required of optical transmission and perform data transmissions without errors. In order to increase the space transmission power in an optical wireless LAN or optical wireless link, the transmission output itself can be increased at a predetermined transmission beam width or the actual transmission power density can be increased by narrowing the transmission beam width.

[0009] Transmitters and receivers that are more compact and use less power are more desirable in communication devices from the standpoint of user convenience. If the output from the transmitter is reduced, however, the propagation distance of the electromagnetic

waves is shortened. If a communication distance the length of the indoor space can be ensured, a narrower transmission beam and higher transmission power density can be devised. Because indoor optical communication signals in an optical wireless LAN can be propagated in the space where the users reside, increasing the transmission power density is limited only by the health and safety of users.

[0010] Unfortunately, optical communication is not limited to these situations. There is a desire to use optical communication in all situations currently possible using other electromagnetic waves. However, narrowing the transmission beam width or the communication range means obstacles will have more of an adverse effect on communication. This is the negative aspect of optical communication.

[0011] Furthermore, when baseband signals are transmitted in the prior art, the transmission signals reach the lower frequency range. According to an article appearing in IEEE Transactions on Communications (pp. 2085-2094, 1995), most noise ranges from the direct current (DC) to the 500 kHz range when noise occurs due to fluorescent lighting, especially from commonly used inverter-type fluorescent lighting. Because the background light noise from fluorescent light bulbs and incandescent light bulbs overlaps with the transmission signals, measures are needed to make sub-adjustments to frequencies higher than the transmission signals as a carrier in order to effectively eliminate the noise. When high-speed data is transmitted at speeds greater than 10 Mbps, however, the carrier

frequency reaches 10 MHz. Because the light source and light detector bandwidths are inadequate, sub-adjustment is difficult to realize.

[0012]

[Problem Solved by the Invention] In order to accommodate broadband high-speed data communication such as in B-ISDN, the optical transmission beam width has to be narrowed and the transmission power density increased as much as possible within the transmission power density limits. When the beam width becomes narrower, communication obstacles such as people inadvertently crossing the transmission route become unavoidable. This remains a major unresolved issue for high-speed data communication.

[0013] In the case of diffused LAN networks, even when the signals have a narrow transmission beam width and higher communication power density, the power received on the receiving end from the diffused transmission waves reflected off a ceiling plate or reflective plate installed on a wall are weak. Because the effective service range is shorter, several gateway devices have to be connected to a wired network in order to obtain access to external databases.

[0014] If baseband signals are transmitted and the transmission signals overlap with background light noise, it is also difficult to effectively eliminate the noise.

[0015]

[Means of Solving the Problem] In order to solve the problem associated with the prior art, the first invention is a space transmission communication device comprising a transmitter for

converting data into electromagnetic signals with a predetermined bit rate and radiating the signals into space, and a receiver for receiving the electromagnetic signals radiated by the transmitter and regenerating the signals, wherein the device further comprises a reception strength detecting means for detecting the reception strength of the received electromagnetic signals, a bit rate changing means for changing the transmission bit rate in response to the reception strength, and a receiving means for changing the reception bit rate or reception operation for the electromagnetic signals based on the transmission bit rate changed by the bit rate changing means.

[0016] In other words, the space transmission communication device in the first invention is equipped with a function that can change the transmission bit rate on the transmitting end and a function that can receive signals in response to this transmission bit rate on the receiving end.

[0017] Because the device in the first invention has this configuration, the transmitting end can lower the transmission bit rate when an obstacle enters the signal transmission route and weakens the reception strength. When the receiving end receives these transmitted signals and makes adjustments to the transmission bit rate, the reception bit rate is changed. If it is equipped with light-receiving elements constituting a plurality of light-receiving ranges, it can widen the reception field pattern in response to the lower transmission bit rate.

[0018] Because the transmitter and receiver for the device in the first invention can handle signals at different bit rates, when the transmission route is temporarily blocked and high-speed data cannot be received at the high bit rate using the required reception power, the transmission bit rate is lowered by performing a switching operation, and communication is switched to low speed transmission for a transmission beam range with a lower power density (i.e., the beam range on the periphery of the center). The effect of the obstruction in the transmission route is avoided, communication at the minimum required level is ensured, and the suspension of communication is avoided.

[0019] Because the device in the first invention can resume high-speed data transmissions at a longer communication distance immediately after the obstacle is removed by simply switching between transmission signals with different bit rates, a plurality of /4 gateway devices connected to a wired outside network do not have to be installed as in the prior art.

[0020] The second invention is a space transmission communication device for converting data to optical signals, radiating these signals into space, and regenerating the data incorporated into the optical signals propagated through space, wherein the propagated data is baseband signals, wherein these baseband signals are aB1C (a: natural number; $a > 1$), bBcB (b, c: natural numbers; $c = b + 1$) or DdB1M (d: natural number; $d > 1$) encoded, and wherein the low frequency range of the receiver is blocked.

[0021] The space transmission communication device in the second invention does not change the transmission bit rate in response to the reception strength, but encodes the baseband transmission signals to allow for good data transmission and reception even when the lower frequency range with background light noise is cut off.

[0022]

[Embodiment of the Invention] The following is a detailed explanation of embodiments of the space transmission communication device of the present invention with reference to the drawings.

[0023] (1st Embodiment) FIG 1 is a diagram showing an optical wireless LAN using the space transmission communication device in the first embodiment. Here, the plurality of optical transceivers 1 (11, 12, ..., 1N) in the room are connected to terminal devices 2 (21, 22, ..., 2N) consisting of personal computers or gateway devices to form an optical wireless LAN able to perform digital transmissions at a transmission rate of 100 Mbps. Communication between the optical transceivers 1 (11, 12, ..., 1N) is performed by diffused transmission signals reflected off a reflective plate 3 on the ceiling.

[0024] This diffused optical wireless LAN has a simple configuration and does not require a special functioning device such as a master device installed on the ceiling. The optical transceivers 1 (11, 12, ..., 1N) are configured so that optical signals are directed towards the reflective plate 3 on the ceiling, and so that the light reflected off the reflective plate 3 can be received. At least one of the terminal devices 2 (21, 22, ..., 2N) is a gateway

device (gateway device 23 in FIG 1), and this device is connected to the internet via a wired network (not shown).

[0025] FIG 2 is a block diagram of the optical transceivers 1 (11, 12, ..., 1N) in FIG 1. The receiver 1A in the optical transceiver 1 (11, 12, ..., 1N) receives light signals modulated using RZ-encoded high-speed data. The transmitted optical signals received via the reflective plate 3 in FIG 1 are focused via lens 1A1 onto the surface of the light-receiving element 1A2 of a photoelectric converter consisting of a photodiode (PD). Optical signals are converted to electrical signals by the light-receiving element 1A2. After the electrical signals have been amplified by the front end amplifier 1A3, they are supplied to the phase control circuit 1A4 and the first changeover switch 1A5.

[0026] The phase control circuit 1A4 determines the bit rate of the inputted signals, and generates switch control signal (a) to control the first changeover switch 1A5 based on the results of the determination.

[0027] The first changeover switch 1A5 is connected to a plurality of band-limiting filters 1A6 (two filters 1A61, 1A62 in this embodiment). A switch control signal (a) is received from the phase control circuit 1A4, and a filter is selected and connected based on the bit rate of the inputted signals. Inputted signals with the noise component removed by the selected and connected filter 1A6 are supplied to the identifier 1A7.

[0028] The phase control circuit 1A4 is also connected to a plurality of oscillators 1A9 (two oscillators 1A91, 1A92 in this embodiment) via the second changeover switch 1A8. Because the second changeover switch 1A8 receives the switch control signal (a) based on the bit rate determination results from the phase control circuit 1A4 to select and connect an oscillator based on the bit rate of the inputted signals from the oscillators 1A9, the phase control circuit 1A4 introduces oscillation frequency signals corresponding to the bit rate of the inputted signals from the oscillator 1A9, generates a clock signal (b) adjusted to the phase of the inputted signals, and supplies these signals to the identifier 1A7. The identifier 1A7 introduces the reception signals from the filter 1A6 and the clock signal (b) from the phase control circuit 1A4, generates 0/1 digital signals (c), and supplies these signal to the terminal device 2.

[0029] The phase control circuit 1A4 also introduces a transmission bit rate switch control signal (d) and transmits this to the terminal device 2 in order to announce the bit rate switching change performed on the transmitting end based on the change in reception power strength to the receiver 1A. After receiving this transmission bit rate switch control signal (d), the terminal device 2 sends transmission bit rate switching change notice signals to the other communication devices via transmitter 1B. The transmission bit rate switch control signal (d) is not generated by the phase control circuit 1A4, but is generated either by the terminal device 2 itself or is generated based on a transmission bit rate switching

announcement from another communication device. By supplying this to the phase control circuit 1A4, the switching of the first and second changeover switches 1A5, 1A8 can be controlled.

[0030] Next, the transmitter 1B receives the information signal (e) to be transmitted from the terminal device 2 and stores the signal temporarily in the buffer 1B1. The selection circuit 1B2 successively retrieves the signals based on the transmission control signal (f) from the terminal device 2, and these signals are supplied to the driver circuit 1B3. The driver circuit 1B3 supplies current based on the information signal (e) to the laser diode (LD) 1B4, and transmission optical signals are generated and introduced from the laser diode (LD) 1B4 based on the information signal (e). The transmission beam diameter is controlled as necessary by the lens 1B5 and these transmission optical signals are radiated towards the reflective plate 3.

[0031] A bias current is supplied to the laser diode 1B4 from /5 the bias power source 1B6. The lens 1B5 should be configured with the lens 1A1 to the receiver 1A in order to make the transceiver 1 more compact. Also, normally, all of the signals stored in the buffer 1B1 are retrieved by the selection circuit 1B2, and supplied to the driver circuit 1B3. However, when the bit rate control signal (d) indicates a low bit rate transmission, minimum requirement signals or high priority signals are selected and retrieved from the buffer 1B1 by the selection circuit 1B2, and these are supplied to the driver circuit 1B3.

[0032] Either the information used to make the selection is supplied from the terminal device 2 as signal (g), or a determination is made by the selection circuit 1B2 and signal (g) indicating transmission or discard information is supplied to the terminal device 2. Because transmitted information and other information can be reliably grasped by the terminal device 2, transmission reliability is ensured and resends are made easy.

[0033] If the communication circuit is no good due to an obstacle, the device switches from a high bit rate to a low bit rate and transmits signals. Low bit rate transmissions use a laser beam to the outside of the central portion of the beam (main beam) used during normal transmission. Therefore, by controlling the amount of light able to leak to the outside of the main beam, the transmitter 1B is able to perform low bit rate communication more reliably.

[0034] Because the periphery of the laser diode 1B4 usually scatters and reflects some light from the laser diode 1B4 in the modules for the transmitter 1B, most of the beam transmitted to the reflective plate 3 is along a light path somewhat different from the main beam. However, this beam tends to have a large level change due to changes in temperature, and the amount of light tends to vary by module. In the transmitter 1B in FIG 2, some of the light from the laser diode 1B4 reaches the reflective plate 1B7, and the optical transmission power is intentionally divided around the periphery of the main beam. This configuration ensures minimum transmission power. Here, the strength pattern of the laser beam is slightly distorted.

Ideally, as shown in FIG 3, a step-shaped laser beam pattern should be formed. This can be realized by using a program in the lens.

[0035] In the first embodiment, the transmitter 1B on the other side prepares a predetermined number of transmission bit rates. However, because the reception strength on the receiver 1A end receiving this transmission bit rate can change suddenly due to an obstacle, the transmitter 1B on the other end is generally set to three different transmission rates: 100 Mbps, 1.5 Mbps and 66 kbps. This is usually sufficient, but finer settings are also possible. Because the rest of the bit rates remain unused, because the actual reception level would not be much better even if they were used, and because installing a large number of filters 1A6 for the different bit rates in the receiver 1A would be difficult, most bit rate settings are not used.

[0036] The conditions for transmission bit rate switching determined by the phase control circuit 1A4, namely, the conditions for forming a transmission bit rate switch control signal (a), should be agreed to beforehand by arrangement with the other communication devices. However, a reception power detection circuit can also be installed in the output portion of the front end amp 1A3 in the receiver 1A to monitor the output power of the front end amp 1A3 and change the transmission bit rate on the transmitting end in response to the change in the received optical power.

[0037] Therefore, the receiver 1A determines the reception state of the signals based on the fixed transmission power from the other

communication devices. If the receiver 1A is moving away from the reflective plate 3, the optical power received by the receiver 1A becomes lower. In this situation, reception at a transmission rate of 100 Mbps cannot be maintained, and the transmission rate is lowered to, for example, 384 kbps, on the receiving end. After receiving the transmission signals, the phase control circuit 1A4 in the receiver 1A determines the transmission bit rate, and switches the bandwidth-restricted filter 1A6 based on the switch control signal (a).

[0038] Because the receiver 1A usually can communicate over longer distances at a reserve reception sensitivity of 20 dB or more, lowering the transmission rate makes the transmission of large data capacity information such as image information very difficult. However, transmission of small data capacity information such as audio information can be maintained.

[0039] If the receiver 1A in the first embodiment is used most of the time for low capacity data communication, but the receiver 1A is taken to a location with low reception signal strength and the user has to receive large capacity data such as a movie using the receiver 1A, the receiver 1A has to be moved closer to the reflective plate 3 to a position where the required reception strength can be obtained.

[0040] If there are several optical transceivers 1 (11, 12, ..., 1N), the optical transceivers 1 (11, 12, ..., 1N) requiring relatively frequent broadband communication of high-speed data are divided from the low-speed data transceivers, and the high-speed data transceivers are concentrated near the reflective plate 3. This improves the

utilization efficiency of the region within a range limited to a room supported by a single optical wireless LAN.

[0041] Also, if a portion of the laser beam is blocked by a person and communication at a transmission speed of 100 Mbps is temporarily impossible during multimedia communication such as a personal computer TV conference conducted via the optical wireless LAN using the terminals 2 (21, 22, ..., 2N), the application in the terminals 2 (21, 22, ..., 2N) suspends transmission of large transmission capacity information such as face images and image information such as graphics, but continues transmission of small transmission capacity information in a narrower bandwidth such as /6
voice and text.

[0042] However, if diffused space transmission communication is performed using a reflective plate 3 on the ceiling, it is limited to the multiplication factor of the lens 1A1. Therefore, the light image focused by the lens 1A1 and formed on the light-receiving surface of the light-receiving element 1A2 tends to be greater. When the transmitted light is reflected by the reflective plate 3 on the ceiling, some light coherence is lost and the image on the light-receiving surface tends to become wider.

[0043] However, in the case of an optical wireless link with a transmission rate greater than several dozen Mbps, if the light-receiving element 1A2 is a photodiode, a smaller diameter light-receiving surface has properties making high-speed data operations easier. Therefore, the diameter of the light-receiving element 1A2

should be as small as possible. However, because a light-receiving element 1A2 with a smaller diameter has a narrower incoming direction range for optical signals to be received and a narrower reception field, if any obstacle blocks the main portion of the transmission route (main beam), even the incoming transmission signals arriving via the outside of the obstacle tend not to be picked up by the light-receiving surface and are not received.

[0044] If the reception field pattern of the receiver 1A is temporarily narrowed, the image is similar to what happens when some of the transmission route is blocked by an obstacle blocking the main portion of the transmission route. Here, a switch control signal (d) for the bit rate introduced from the phase control circuit 1A4 cannot be received even when the transmission bit rate switch is lowered by the fall back function.

[0045] FIG 4 is a perspective view of a light-receiving element 1A2 consisting of a photodiode. In FIG 4, the photoelectric converter in the light-receiving element 1A2 is not simply the light-receiving surface 1A2b for receiving the main beam A on the substrate 1A2a. It is also wired to a portion 1A2c extending to the outside in a square shape so that signals B directed at the portion to the outside can be received. This light-receiving element 1A2 has the same structure as the substrate 1A2a even in the portion outside of the normal element portion. When electrodes 1A2d are installed, the photoelectric conversion can be performed even when there is some magnification factor deterioration.

[0046] The electrode 1A2e at the terminal on the current output end is connected to the front end amp 1A3 by wiring pattern 1A2f. The normal light-receiving surface portion 1A2b in the center of one of the terminal has a reverse bias applied via electrode 1A2g, and the periphery is grounded by electrode 1A2d. The center of the beam or the main beam A is for normal high-power signals and high-speed signals, signal B incoming from the beam periphery or to the outside of the main beam is not for high-power signals or high-speed signals at all. It is for low-power signals or low-speed signals only. By using a light-receiving element 1A2 with this configuration, high-speed signals can be photoelectrically converted and received in the center. When signals reaching the periphery are the only ones received because an obstacle is blocking the main portion of the optical signal beam, the light can be picked up by the outside portion 1A2c and photoelectrically converted. This widens the reception field pattern equivalently so reception can be continued using weak low-speed signals.

[0047] By installing a receiving means for low-speed communication corresponding to a beam on the periphery of the main reception region or transmission beam periphery, a special mechanical portion is not required, and a compact device can handle optical transmissions without a complicated photoelectric converter and minimal front end amp configuration.

[0048] The light-receiving element 1A2 in FIG 4 is wired to the portion 1A2c to the outside of the normal light-receiving surface

portion 1A2b to widen the receiving field pattern so that signals B coming in to the portion on the outside can be received. The reception field pattern can also be widened by arranging multiple photodiodes in the shape of an array.

[0049] (2nd Embodiment) FIG 5 is a partial perspective view used to explain the space transmission communication device in the second embodiment of the present invention. This figure shows the light-receiving element 1A2, which differs from the one in the first embodiment. In other words, a plurality of photodiodes 1A2h1, 1A2h2, ..., 1A2h7 are arranged in the shape of an array on a substrate 1A2a. The region with the photodiodes 1A2h1, 1A2h2, ..., 1A2h7 with a bias applied is divided, and the same functions as those performed by the light-receiving element 1A2 in FIG 4 can be obtained by switching between them.

[0050] These photodiodes 1A2h1, 1A2h2, ..., 1A2h7 have specific photoelectric conversion factors and receive high-speed data separately. The reception sensitivity during fall back when the field is widened is better than that of the first embodiment in FIG 4.

[0051] A reception power detection circuit is installed on the output end of the photodiodes 1A2h1, 1A2h2, ..., 1A2h7, and configured to apply a bias only to the photodiode element with the highest reception power. If the angle of incidence for the light signals shifts slightly and the incoming beam diameter changes somewhat, or if strong obstructing light such as sunlight strikes in the reception field, the field of the receiver 1A can be controlled equivalently.

This aligns the light-receiving element 1A2 in the transmission laser beam direction and increases the photoelectric conversion factor with respect to the light signals aligned with the portion less affected by the obstructing light.

[0052] If signals with different bit rates become mixed together in a space transmission communication device in the first and second embodiments for an optical wireless LAN, the transmission signals from the other communication device have to be easily detectable whatever the bit rate is in order to keep the transmission of some light /7
signals from conflicting with the transmission of other light signals.

[0053] If, for example, a transceiver is communicating at a low bit rate and a no-signal state is detected from the other transceiver for a long period of time, the device might begin a new transmission and end up dealing with a mixed transmission state. In order to avoid mixed transmissions, a pulse signal corresponding to 100 Mbps should be inserted every multiple µs interval to tell the other transceiver that the transmission route is still in use, even when the low bit rate transmission is "0" (i.e., "light ON" for data signal "1" and "light OFF" for data signal "0"). Insertion of the remaining pulse signals (100 Mbps pulse signals every multiple µs interval) is not obstructed on the low bit rate transmitting end because the pulse width is short and the transmission power low. By limiting the transmission packet length during low bit rate transmission (e.g., if the other node has a 1 ms delay buffer), the transmission route can be

occupied by a low bit rate transmission to keep the buffer from becoming full.

[0054] In the first embodiment shown in FIG 4, output electrode 1A2e in the light-receiving element 1A2 is shared by the normal light-receiving surface portion 1A2b and the outside portion 1A2c, and is connected to one front end amp 1A3. This has the same effect as when the main light-receiving portion 1A2b is separated from the outside light-receiving portion 1A2c and both are connected to separate front end amps 1A3.

[0055] (3rd Embodiment) FIG 6 is a block diagram used to explain the receiver 1A for the space transmission communication device in the third embodiment of the present invention. In the receiver 1A shown in FIG 6, the main light-receiving element 1A21 and the subordinate light-receiving element 1A22 are connected to a first and second front end amp 1A31 and 1A32, respectively.

[0056] The first front end amp 1A31 or the second front end amp 1A32 is connected directly to a synthesis circuit 1A11 via a switch 1A10. After the output from the first and second front end amps 1A31, 1A32 has been synthesized if necessary, the output is supplied to the identifier 1A7 via filter 1A51.

[0057] Because switch 1A10 receives switch control signal (a) from the phase control circuit 1A4 and supplies the output signals from light-receiving elements 1A21, 1A22 to a synthesis circuit 1A11, switch control can be used to remove the effect of parasitic capacitance in light-receiving element 1A22 from the signals outputted

from the main light-receiving element 1A21 for high-speed signal reception. As a result, signals with stable reception properties can be obtained. By initially aligning the band of the second front end amp 1A32 corresponding to subordinate light-receiving element 1A22 with, for example, a transmission rate of 384 Kbps, high-range noise can be suppressed. This makes the filter switching in FIG 2 unnecessary, and simplifies the configuration.

[0058] In the configuration shown in FIG 6, the output from the first and second front end amps 1A31, 1A32 is selectively synthesized. However, switch 1A10 can be omitted to perform constant signal synthesis. Also, the two-system output from the first and second front end amp 1A31, 1A32 can be synthesized in front of filter 1A5 in this embodiment. In circuit integration, the two-system output can be extended to filter 1A51 or the identifier 1A7 for subsequent synthesis or switching.

[0059] In this configuration, the number of front end amps 1A31, 1A32 and switches 1A10 can be increased. However, making the main light-receiving element 1A21, subordinate light-receiving element 1A22, the first front end amp 1A31, and the second front end amp 1A32 monolithic, increases the amount of wiring and makes the configuration more complex. This, therefore, should be avoided.

[0060] In this embodiment, the reception operation corresponding to the transmission bit rate change in the receiver 1A selectively switches the light-receiving field pattern for the light-receiving portion of the light-receiving element 1A2 or performs synthesis.

However, as shown in FIG 7, the same function and effect can be obtained by moving the position of the receiving lens 1A based on changes in the transmission bit rate.

[0061] (4th Embodiment) FIG 7 is a block diagram of the receiver for the space transmission communication device in the fourth embodiment of the invention. An adjustment mechanism 1A12 moves the lens 1A1 used to focus incoming light signals on the light-receiving element 1A2 slightly in the direction of arrow Y. Here, the position of the lens 1A1 is moved perpendicular to the light axis. The light-receiving region of the light-receiving element 1A2 has a main component in only one location. Even when the aspect of the lens 1A1 is moved by controlling the adjustment mechanism 1A12, the focal position of the lens 1A1 is usually over the light-receiving element 1A2. This is configured so that received light can be converted even when light signals are received at an angle slightly offset from the normal angle. Therefore, the power detection circuit 1A13 in the receiver 1A can detect the reception power, and control the adjustment mechanism 1A12 via the controller 1A14 based on the detection signals to adjust the lens 1A1 and increase the light power on the light-receiving surface.

[0062] If the transmission route is blocked by some obstacle, the controller 1A14 moves the lens 1A1 to make sure more of the optical transmission signals leaking around the obstacle are captured by the light-receiving element 1A2. In other words, the reception field pattern direction of the receiver 1A is deflected to the outside of

the obstacle by moving the lens 1A1 in order to ensure reception of transmission signals at a low bit rate.

[0063] This differs from the light-emitting element 1A2 in /8 FIG 5 in that there is no change in the location used by the receiver 1A to obtain the received light pattern. The adjustment mechanism 1A12 used to move the lens 1A1 slightly can be a servo mechanism operated by a well-known feed back circuit. The lens 1A1 should be able to move in any direction centered on the light axis, whether vertical or horizontal. If a transmission route in the indoor wireless route is often blocked by the movement of people, the direction of movement by the lens 1A1 can be adjusted in the direction of movement by the people, i.e., horizontally. Also, a low bit rate transmission signal reception route can be selected by moving the lens 1A1, the response to the reception route is determined based on the relative positional relationship between the lens 1A1 and the light-receiving element 1A2. If the control system is configured so that the lens 1A1 is fixed and the light-receiving element 1A2 is moved slightly, the same function and effect can be obtained.

[0064] As for the signals received via the front end amp 1A3 in this embodiment, data signals analog-processed by the clock signal (b) from the phase control circuit 1A4 are reproduced, but the signals received via the front end amp 1A3 can be processed by the digital calculation circuit and reproduced to obtain the same effect.

[0065] (5th Embodiment) FIG 8 is a block diagram used to explain the light receiver 1A for the space transmission communication device

in the fifth embodiment of the present invention. This light receiver 1A has a digital calculation circuit 1A15 connected to the output from the front end amp 1A3, and a change in the calculation program can be used to adjust easily to the transmission bit rate change and transmission encoding format.

[0066] In other words, light signals received via lens 1A1 and light-receiving element 1A2 are amplified by front end amp 1A3 and supplied to the digital calculation circuit 1A15.

[0067] In the digital calculation circuit 1A15, the incoming signals are quantified by a high-speed digital-to-analog converter 1A15a. Because the signals pre-identification contain signal noise, the analog-to-digital converter 1A15a has a sufficient sampling speed and the necessary dynamic range in terms of precision. The required processing is performed by the digital signal processor (DSP) main calculation circuit 1A15b based on the output from the analog-to-digital converter 1A15a.

[0068] The DSP 1A15b determines the bit rate of the received signals, and then limits the band based on the bit rate to reproduce the digital information signals. The reproduced information signals are converted to serial signals by the parallel-serial (PS) converter 1A15c and outputted to the terminal device 2. The DSP 1A15b controls the clock generation circuit 1A15d, generates clock signals based on the transmission bit rate, and supplies the signals to the terminal device 2. Required information such as bit rate control signals are also received. This receiver 1A can be configured like the light

receiver in FIG 6 by installing a plurality of analog-to-digital converters 1A15a. The fine movement control of the lens can be performed by the calculating circuit 1A15 as shown in FIG 7.

[0069] The first through fifth embodiments were explained using light for the transmitted signals. An embodiment will now be explained using electromagnetic waves such as millimeter waves and microwaves.

[0070] (6th Embodiment) FIG 9 is a block diagram of the device in the sixth embodiment of the present invention. First, the signal receiving circuit 1A16 in the receiver 1 has an antenna and high-frequency level with an RF unit. This circuit converts the transmitted electromagnetic waves into electric signals, and then amplifies the signals and performs frequency conversion if necessary. The resulting signals are supplied to the switch control circuit 1A17 and the first changeover switch 1A5. The switch control circuit 1A17 determines the transmission speed of the received signals, introduces a switch control signal (a), and controls the first changeover switch 1A5. It also generates a transmission bit rate switch control signal (d) and supplies this to the terminal device 2.

[0071] Signal processing circuits 1A18 are connected to the first changeover switch 1A5, and the signal processing circuit 1A18. A plurality of signal processing circuits 1A18 (two in this embodiment: the first and second signal processing circuits 1A181, 1A182) are installed based on the number of predetermined transmission rate divisions. After filtering the signals inside, removing noise from the local oscillator, and demodulating/identifying the signals, the

received signals are reproduced. The reproduced digital signals (c) and local oscillator clock signals (b) are supplied to the terminal device 2 via a first changeover switch 1A5.

[0072] The switch control circuit 1A17 is configured so that the signals received from the signal reception signal 1A16 are introduced and switch control signals (a) are generated based on the transmission bit rate. However, as in the first embodiment, transmission bit rate switch control signals (d) are supplied from the terminal device 2 and switch control signals (a) are generated. The digital signals (c) reproduced by the signal processing circuit 1A18 (not shown) are introduced, and switch control signals (a) are generated and supplied to the first changeover switch 1A5 based on the monitoring of these digital signals (c). The first changeover switch 1A5 is configured so that the changeover switch between signal processing circuit 1A16 and signal processing circuit 1A18 are eliminated, and the received signals are supplied to both the first and second signal processing circuits 1A181, 1A182.

[0073] Signal processing circuit 1A18 can be replaced by the digital calculation circuit 1A15 in the fifth embodiment shown in FIG 8. Here, a changeover switch 1A5 is not required.

[0074] In either case, when an obstruction occurs in the space transmission route making normal high-speed transmission impossible and a switch to a lower transmission speed is required, the switch control circuit 1A17 in a receiver 1A configured in this manner receives generates switch signals or has them supplied from the /9

terminal device 2.

[0075] The transmitter 1B receives the information signals (e) to be transmitted from the terminal device 2 and stores these signals in the buffer 1B1. The selection circuit 1B2 successively retrieves these signals from the terminal device 2 in response to transmission control signals (f), and supplies these signals to the transmission signal generating circuit 1B8.

[0076] Because the transmission signal generating circuit 1B8 is actually a plurality of transmission signal generating circuits (two in this embodiment: first and second signal generating circuits 1B181, 1B182) and because the transmission signals are generated based on a predetermined transmission rate and modulation method, the generated transmission signals are radiated into space from the signal transmission circuit 1B10 with a transmission antenna towards the reflective plate 3 via a transmission changeover switch 1B9. In this embodiment, as in the case of an optical transmission, the signal transmission circuit 1B10 is configured to switch the transmission antenna angle of radiation and the transmission beam pattern. This allows transmission route obstructions to be handled more effectively. Because the signal receiving system between the selection circuit 1B2 and the terminal device 2 has the same configuration as shown in FIG 2, a detailed explanation has been omitted.

[0077] (7th Embodiment) In this embodiment, return-to-zero (RZ) encoded data is transmitted. However, non-return-to-zero (NRZ) encoded data or multiple-value (three or four-value) encoded signals can be

transmitted instead of RZ encoded signals. Scrambling or other secure encoding technologies such as bit sequence independence (BSI) can be used in the transmission of these signals to remove background light noise. Scrambling and BSI secure encoding technologies were developed to make signal mark and space encoding continuous, and to prevent the elimination of timing clocks. In the space transmission communication device in the seventh embodiment of the present invention, these advantages are maintained and background light noise can be effectively eliminated in the low frequency range.

[0078] The following is a description of a BSI secure encoding system that can be applied to the present invention.

[0079] A typical encoding method is aB1C (a Binary with 1 Complement insertion) encoding (a: natural number). Every "a" bits, a single complement bit is inserted right in front of the bit.

[0080] Another encoding method is bBcB encoding (b, c: natural numbers). Here, a binary sequence is converted into a c-bit binary block every b bits such as mark rate approaches 1/2.

[0081] Another method is DdB1M (Differential d Binary with 1 Mark insertion) encoding (d: natural number). A 1 bit mark signal is inserted every "d" bits in the signal sequence (original sequence) to be transmitted. This encoding is generated by performing a finite sum calculation between the signal sequence and the previous 1 bit transmission code.

[0082] Other methods include eB1P (e Binary with 1 Parity) (e: natural number) and PMSI (Periodic Mark and Space Insertion). The CMI

and DMI encoding methods can also be used. However, redundancy problems occur with these encoding methods.

[0083] In aB1C encoding, the original information rate is a/a(a+1) of the bit rate. In bBcB encoding, the original information rate is b/c the bit rate. In DdB1M encoding, the original information rate is d/(d+1). However, in these three encoding methods, if the conditions a > 1, c = b+1, d > 1 are met, respectively, the rate of increase for the bit rate is suppressed, and the background light noise is cut off.

[0084] Bi-phase encoding such as CMI and DMI, in which the original information rate is 1/2 the bit rate, should not be used in systems with compact data transmission ranges.

[0085] Even when the BSI secure encoding method is used, a deterioration may occur due to low range blocking when a repeating pattern is transmitted. This can be effectively avoided by installing a low range blocking compensation circuit such as a clamp circuit in the receiver. A clamp circuit performs a peak-bottom hold after a set time constant of a sufficient length longer than the bit length. This can determine the mark or space identification level.

[0086] In systems using simple scrambling, the maximum code continuation is prescribed probabilistically. However, maximum code continuation can be prescribed if scrambling is used with BSI secure encoding. Because it is difficult to generate a repeating pattern, background light noise is effectively cut off.

[0087] The following is an explanation of the effect of low-range blocking of encoded signals with reference to FIG 10. FIG 10 (a) shows the time waveform of the original signals. Here, the mark indicates a continuous number of bits of a sufficient length, and the space also indicates a continuous number of bits of a sufficient length. In FIG 10 (b), the original signals have undergone aB1C encoding. (In this figure, a = 5). In FIG 10 (c), the aB1C encoded signals in FIG 10 (b) have the lower range blocked. Because the signals in FIG 10 (c) do not contain the direct current component, a mark-space level change occurs immediately after the switch from mark to space. The speed of the change depends on the low-range block cutoff frequency. /10

[0088] The clamp circuit for low pass blocking compensation in the receiver sufficiently increases the time constant for peak and bottom detection for identification level confirmation to withstand same code continuation. When the level change for (a) bit continuation is m, the level change due to low pass blocking does not cause an identification error if the (a) bit continuation is (0.5 + m/2).

[0089] When the bit read is R and the (a) bit time interval is a/R, the time constant (τ) for the level change due to low pass blocking is the following.

[Equation 1]

Using $\exp\left(-\frac{a}{R \cdot \tau}\right) = (0.5 + m/2)$,

the following obtains: $\tau = \frac{-a}{R \cdot \ln(0.5 + m/2)}$

So the cutoff frequency f for the low pass blocking is:

$$f = \frac{1}{2 \cdot \pi \cdot \tau} = \frac{R \cdot \ln(0.5 + m/2)}{-2 \cdot \pi \cdot a} \quad \cdots (1)$$

If, for example, the bit rate R is 100 Mbps ($R = 100 \times 10^6$) and the level change of the (a) bit continuation m is 10% (m = 0.1), the cutoff is 950 kHz for 10B1C and 1.9 MHz for 5B1C. However, this is restricted to situations where the light reception power is high and the S/N is ratio sufficiently high. Preferably, the low range is confirmed up to 1/2 the cutoff frequency f provided in Equation (1).

[0090] Because a laser diode (LD) can perform higher speed modulation and output than a light emitting diode (LED), it is particularly well suited to use in a high-speed space transmission and communication device. If a laser diode (LD) is used in the light emitting element inside the transmitter and encoding technology is employed, highly efficient communication is possible. Of course, an LED can be used as well.

[0091] The encoding is also valid even when the transmission bit rate is changed. In this situation, several methods can be considered. First, there is a method in which the same encoding is used even when the transmission bit rate is changed. This method has the advantage of

a relatively simple circuit configuration. Also, there is a method in which the encoding redundancy is increased when the low bit rate is changed. For example, if there is a change from 10B1C to 2B1C, the background light noise is effectively eliminated regardless of the transmission bit rate. If the bit rate is lowered further, the background light noise cannot be eliminated despite encoding. Here, encoding can be stopped or the method switched to a sub-modulation communication system using a carrier higher than the background light noise band.

[0092] In the embodiments explained above, a function is added to insert transmission signals able to be detected by the receiver from the transmitting end at a high bit rate when the transmitting end uses low bit rate transmission and the non-output time continues beyond a set period of time. This is configured so that collisions can be avoided during communication even when a communication occurs over a 1:N transmission route and high bit rate communication occurs at the same time as low bit rate communication. Also, the baseband transmission signals are encoded, the low pass frequencies with background light noise are cut off, and good data can be transmitted and received.

[0093] In this explanation, the device in the present invention was able to quickly and reliably perform transmission bit rate changes in response to transmission blockage in the communication route between transceivers 1A and 1B, and these transceivers were able to handle high-speed data communication. The devices had transmission and

reception functions able to handle transmission bit rate changes, which means one end had to adapt to the other end in terms of transmission and reception functions. Therefore, the device in the present invention is able to perform communication without any obstructions to the extent that the transmitters and receivers have functions allowing for existing high-speed data transmissions, and to the extent that the communication format and network processing format of the transmitters and receivers are compatible and not only in the case of low-speed data transmission functions.

[0094] As mentioned above, the space transmission communication device in the present invention effectively utilizes the transmitted beam power distribution by controlling the switching process. This makes low bit rate reception in high-speed transmissions more reliable on the receiver end.

[0095] By installing a function for special formation of the peripheral beam portion with a requisite transmission power for low transmission bit rate transmissions on the periphery of the central portion of the transmitted beam forming the transmission signals on the transmission end, the effect on transmission route blockage can be greatly reduced. A significant effect can be obtained even by current and future B-ISDN terminal wiring means.

[0096] In a space transmission communication device that does not change the transmission bit rate in response to reception strength, the baseband transmission signals can be encoded and good data

transmitted and received even when the low pass frequencies in background light noise are cut off.

[0097]

[Effect of the Invention] In the first invention, a single receiver can switch and demodulate signals at a plurality of bit rates. This allows for a minimum level of communication by lowering the transmission bit rate when communication is not possible at the requisite predetermined transmission power because the communication route is too long or temporarily obstructed. /11

[0098] In a system using a receiver for high-speed communication in a narrow field, a light receiving surface for low-speed communication is formed on the periphery of the light receiving element for situations where the main portion of the laser beam cannot be received on the receiving end. Because the receiver can receive using the peripheral portion of the laser beam in a field pattern different from the normal pattern, minimal level communication is possible when the transmission bit rate is lowered.

[0099] It is also configured to ensure the required amount of power on the periphery of the laser beam by controlling the power distribution of the laser beam. This has significant practical effects such as effectively realizing low bit rate reception on the receiver end.

[0100] In the space transmission communication device of the second invention, the transmission bit rate does not change with respect to reception strength. This space transmission communication

device can encode baseband transmission signals and transmit and receive good data even when the low pass frequencies in background light noise are cut off.

[Brief Explanation of the Drawings]

[FIG 1] A configurational diagram showing the wireless optical LAN using the space transmission communication device in the first embodiment of the present invention.

[FIG 2] A block diagram of the light transceiver in the space transmission communication device shown in FIG 1.

[FIG 3] An intensity pattern graph of the laser beam reflected from the light transmitter in the light transceiver shown in FIG 2.

[FIG 4] A perspective view of the light receiving element in the light transceiver shown in FIG 2.

[FIG 5] A perspective view of the light receiving element for the light receiver in the space transmission communication device in the second embodiment of the present invention.

[FIG 6] A configurational diagram showing the light receiver using the space transmission communication device in the third embodiment of the present invention.

[FIG 7] A configurational diagram showing the light receiver using the space transmission communication device in the fourth embodiment of the present invention.

[FIG 8] A configurational diagram showing the light receiver using the space transmission communication device in the fifth embodiment of the present invention.

[FIG 9] A configurational diagram showing the radio transceiver using the space transmission communication device in the sixth embodiment of the present invention.

[FIG 10] A diagram used to explain the effect of encoded signal low pass blocking in the present invention.

[Key to the Drawings]

1, 11, 12, ... 1N Light Transmitter/Receivers

1A Receiver

1A1 Lens

1A2 Light-Receiving Element

1A3 Front End Amp

1A4 Phase Control Circuit

1A6 Filter

1A7 Identifier

1A8 Transmitted Signal Generating Circuit

1A9 Oscillator

1A12 Adjustment Mechanism

1A13 Power Detecting Circuit

1A15 Digital calculation circuit

1A17 Switch Control Circuit

1A18 Signal Processing Circuit

1B Transmitter

1B1 Buffer

1B2 Selecting Circuit

1B4 Laser Diode

1B5 Lens

1B7 Reflective Plate

2, 21, 22, ... 2N Terminal Devices

23 Gateway Device

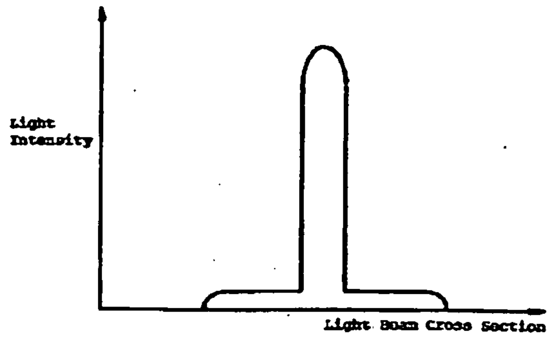
3 Reflecting Plate

a Switch Control Signal

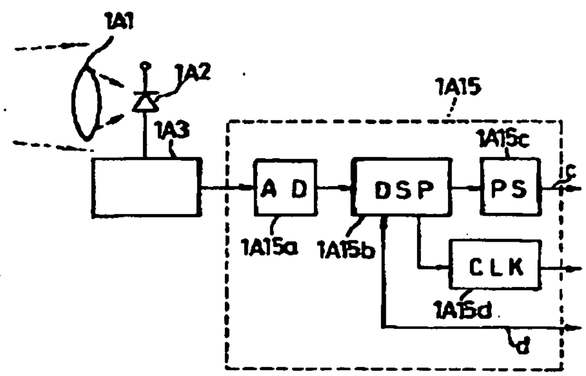
c Digital Signal

d Transmission Bit Rate Switch Control Signal

[FIG 3]

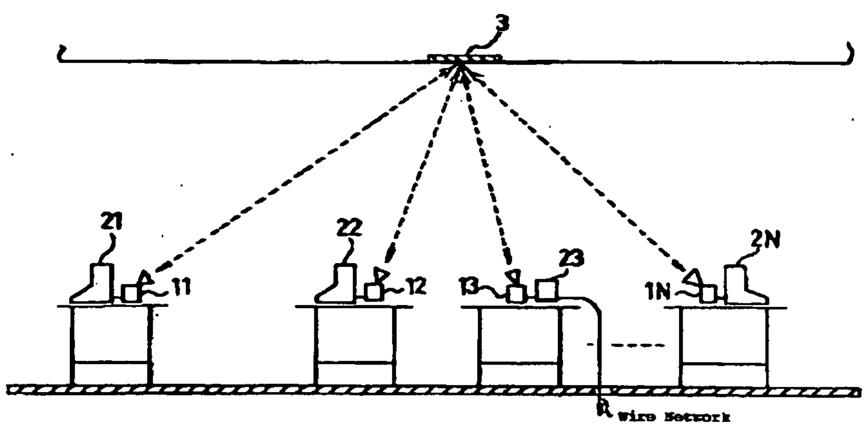


[FIG 8]

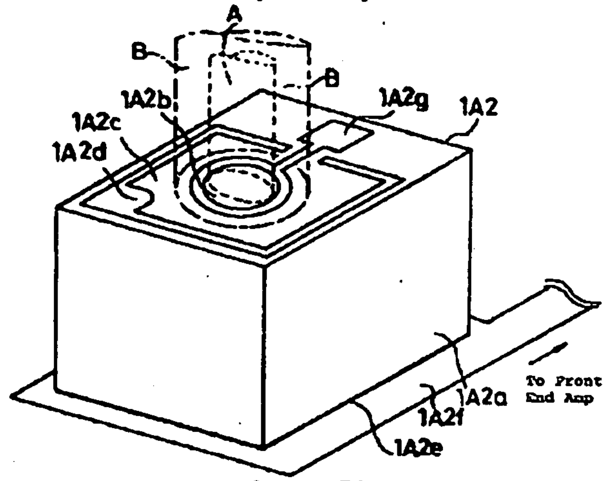


/12

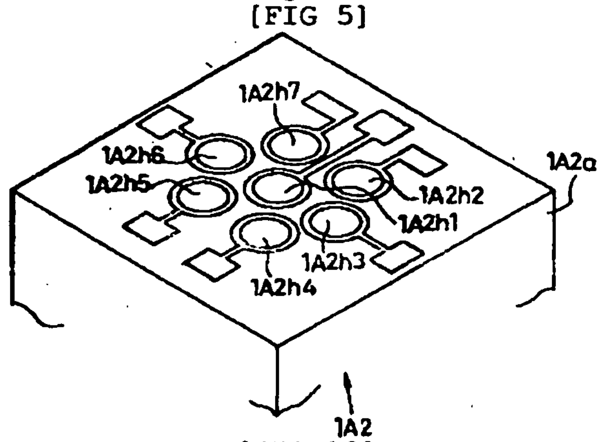
[FIG 1]



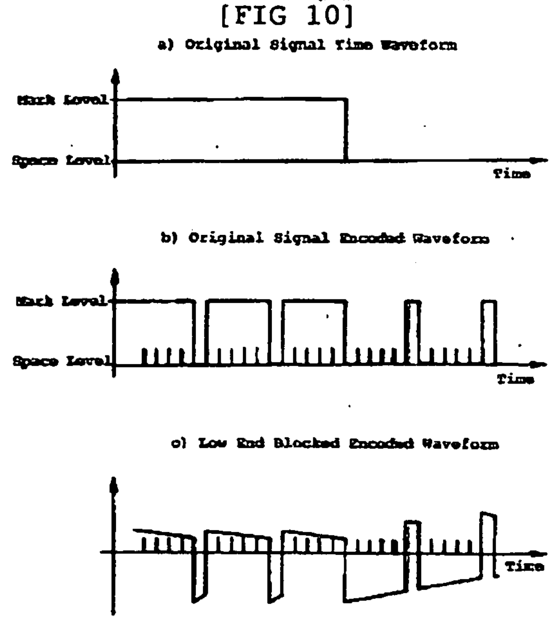
[FIG 4]



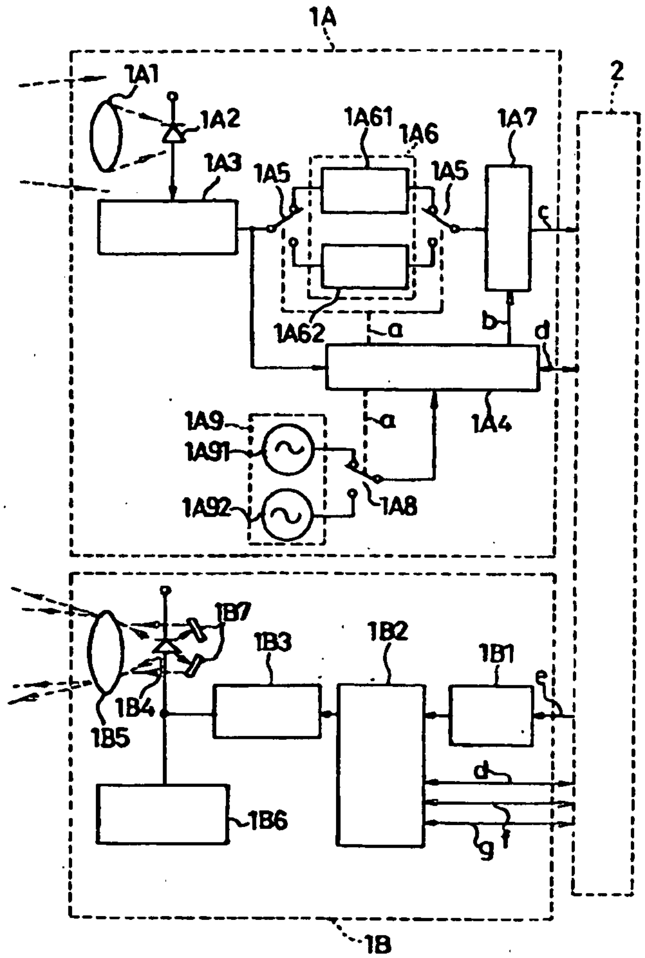
[FIG 5]



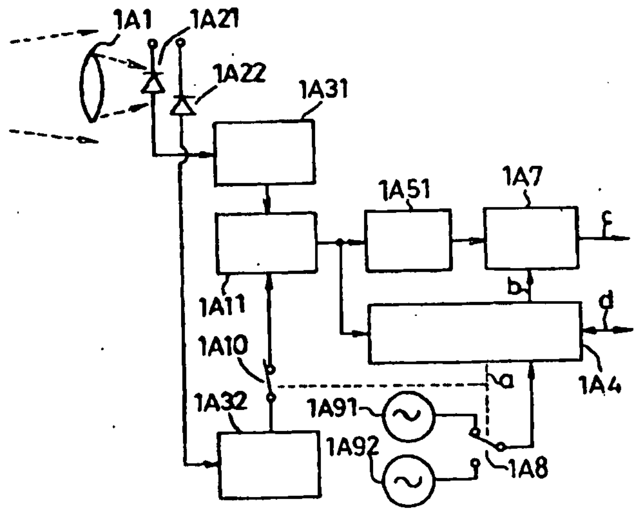
[FIG 10]



[FIG 2]

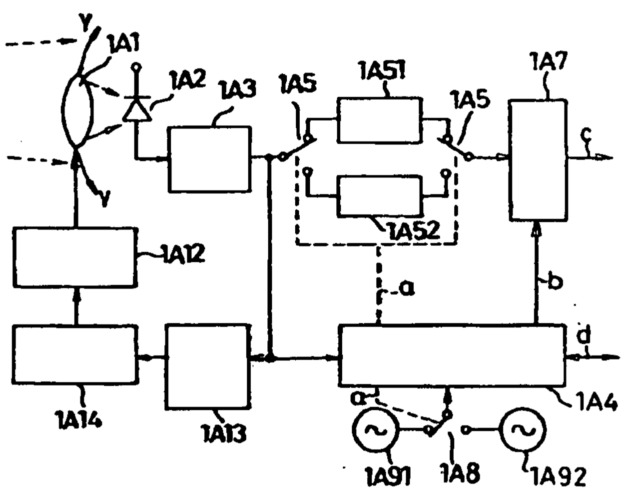

1A
1A1
1A2
1A3
1A5
1A61
1A6
1A5
1A7
2
c
1A62
a
b
d
1A4
1A9
1A91
a
1A8
1A92
1B7
1B3
1B2
1B1
e
1B4
1B5
d
1B6
f
g
1B

[FIG 6]



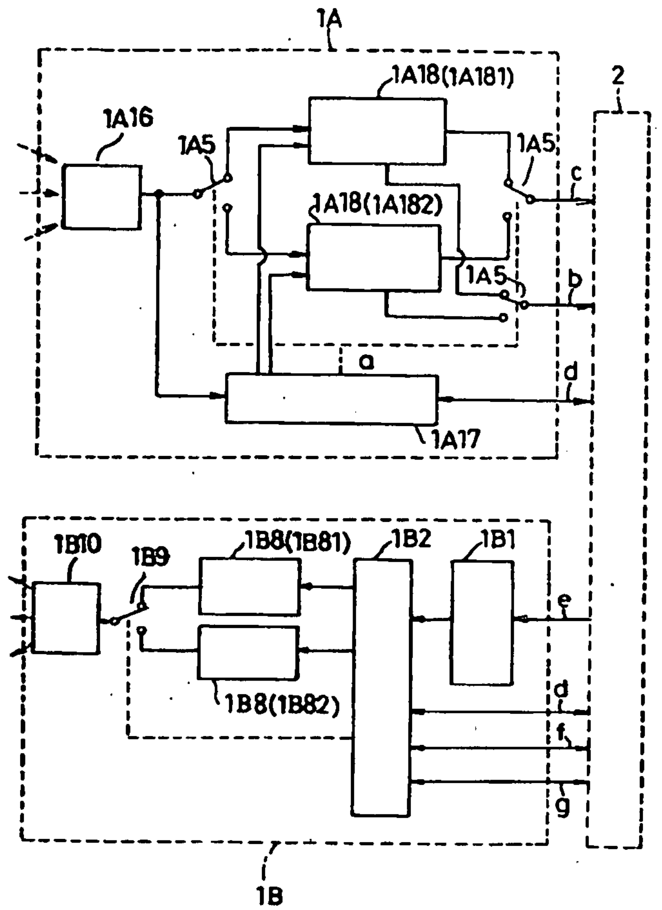
Key: 1A11) Synthesizer Circuit; 1A31) Front End Amp; 1A32) Front End Amp; 1A51) Filter 1

[FIG 7]



Key: 1A14) Controller; 1A51) Filter 1; 1A52) Filter 2

[FIG 9]



Key: 1A16) Signal Receiving Circuit; 1B8) Signal Generating Circuit; 1B10) Signal Transmitting Circuit